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Number 75 — 2 Jun 1947

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**FOUR ARTICLES FROM "HERALD OF THE AIR FLEET,"
ISSUE No 1, 1947**

Prepared By

Documents Branch

CENTRAL INTELLIGENCE GROUP

New War Department Building
21st and Virginia Avenue, N. W.
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COMPLETE TRANSLATION

FOUR ARTICLES FROM "HERALD OF THE AIR FLEET," ISSUE NO 1, 1947

USSR Army Air Forces
Moscow, USSR
Jan 1947

TABLE OF CONTENTS

Editor's Note: Place names in capitals and followed by an asterisk are transliterations from the Russian.

STARTING AIRCRAFT ENGINES UNDER WINTER CONDITIONS

Col G. Senichkin (Engr)
Maj N. Cheremnykh (Engr)

During the last war we gained wide experience in the use of materiel under winter conditions. The main operation stages of the engine and the whole engine-propeller unit of a plane in winter are as follows: preparation of the engine for starting, heating and engine warm-up after starting.

Diluting Oil With Gasoline

One of the chief obstacles in starting an engine is the low temperature of the oil, if it has not been convenient to keep its temperature within the limits necessary for the normal starting and take-off of the plane.

It is well known that the density of all liquids increases when their temperature is lowered. In the case of oil in particular, this often produces a considerable increase in viscosity. When oil is poured into a tank and is in all the oil lines and motor parts, it becomes so thick at low atmospheric temperatures that friction is considerably increased, and it sometimes becomes impossible to start the engine in the normal way.

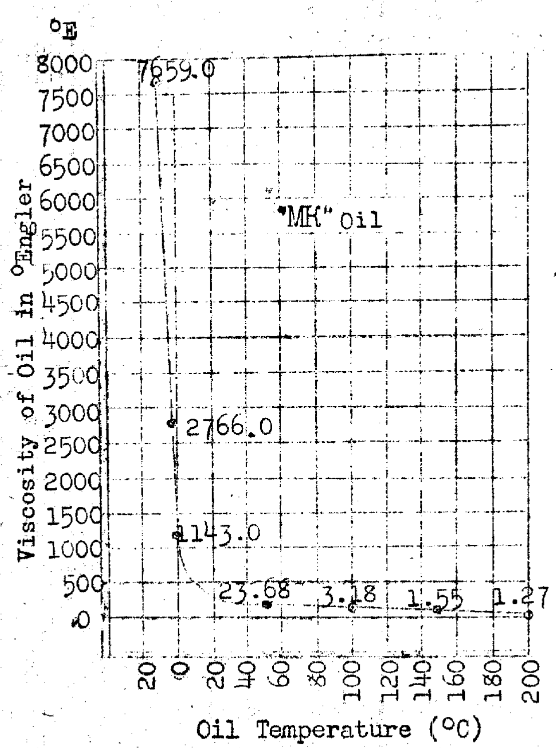


Fig 1

Figure 1 gives a complete picture of the change in oil viscosity with change in temperature; that is, the lower the temperature, the greater the viscosity, and vice versa.

At the same time, the freezing temperature of oil (Author's Note: the temperature at which oil completely loses it mobility) plays a great part in starting an engine, as well as the temperature at which oil can no longer circulate. It is more important for operators to know the latter. It has been proven by experiment that the lowest temperature at which oil can circulate in an engine is minus 8 degrees to minus 10 degrees centigrade for summer oil, and minus 20 degrees centigrade for winter oil.

The maximum viscosity at which the engine can be started is about 5,000 - 6,000 E (EdN: Russian abbreviation; English equivalent not apparent). It is sometimes called starting viscosity.

Consequently, in fueling a plane with oil and in starting the engine, the oil should have good fluidity and mobility. Therefore, it is generally heated before fueling, and the engine is generally warmed before starting up.

To speed up the starting of engines in winter during the last war, the method of diluting the oil with gasoline was used successfully.

Experience shows that МК oil without gasoline dilution can not be used in a temperature below minus 8 to minus 10 degrees centigrade. The same oil under the same circumstances, but with a gasoline dilution of 12.5 percent, normally circulates after starting at temperatures of minus 20 to minus 25 degrees centigrade, even in such an exacting engine as the АШ-82ФН. Thus, summer oils diluted from 12 to 15 percent with gasoline can completely replace special kinds of winter oils.

Diminishing of oil viscosity at low temperatures greatly diminishes the starting torque (Fig 2). This permits increasing the speed of rotation of the crankshaft over the starting capacity. Increasing the rotation speed of the crankshaft in starting has a very favorable effect on the intensity of the electric spark and, consequently, on the speed of starting the engine.

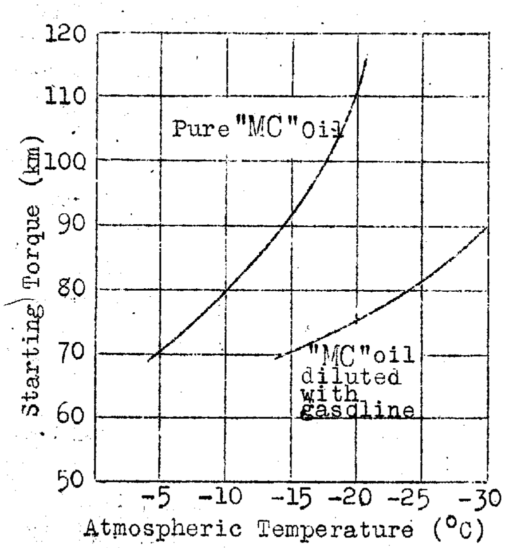


Fig 2

As a result of the initial lowering of viscosity of winter oils, gasoline for diluting them is added in somewhat less quantity than to summer oils. Therefore, starting the engine does not involve difficulties in providing normal lubrication at temperatures above minus 30 to minus 35 degrees centigrade.

A question which may be posed is: can a type of oil be selected which would not require gasoline dilution? Generally speaking, it is quite possible by making various additions to ordinary oil and by proper preparation to make the mechanical properties of such oil similar to those of oil diluted with gasoline.

But then it would be impossible to avoid a lowering of its viscosity due to the normal operating temperatures of the engine, and this is, of course, undesirable.

Oil diluted with gasoline does not have this deficiency, because it recovers its original viscosity fairly rapidly (the gasoline evaporates) after the engine is started, due to the operating temperatures of the engine, as mentioned above. This is one of the chief merits of the gasoline-dilution method.

Fig 3

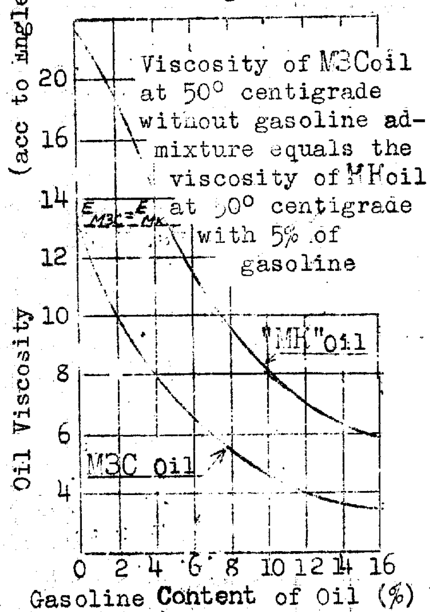
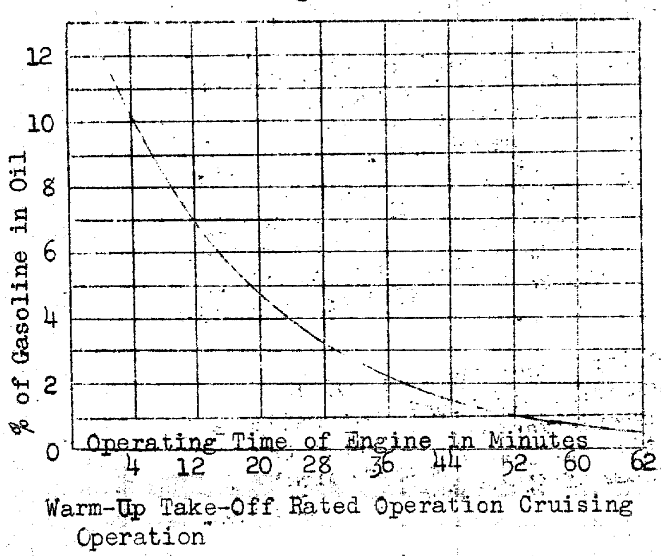


Figure 3 demonstrates the relation of the difference in viscosity of MK and M3C oil to their gasoline content; that is, the viscosity of M3C oil at 0 degrees centigrade with regard to its mechanical properties corresponds to MK oil with a 5-percent addition of gasoline. The graph in figure 4 shows the evaporation rate of gasoline in oil during continuous operation of a АШ-82 ФН engine in a fighter plane. It is evident from the graph that almost half of the gasoline evaporates with the warm-up and testing of the engine.

If the oil has low initial viscosity, relatively many revolutions may be required to warm it up; in which case, the temperature of the oil increases rapidly, but its temperature for the take-off does not need to be so high as that of other oils. This is the second advantage of the gasoline-dilution method, in that it permits warming up the engine in considerably less time. This is easily proven from figure 3, where the difference in oil

Fig 4



viscosity is shown according to the percentage of gasoline content.

The lubrication system of an engine operating on oil diluted with gasoline is checked with an oil-pressure guage. If the oil pressure is not reduced, or does not strongly increase with the increase in revolutions, its feeding to the oil pump is satisfactory, and its flow in the oil lines and through the bearings is proceeding normally.

As operating experience has shown, the gasoline-dilution method is easily acquired by all technicians, mechanics and aviators, as they are graphically convinced that the increase in fluidity of oils considerably reduces friction in the engine when starting under low-temperature conditions and, consequently, facilitates the starting of plane engines.

In applying a gasoline-dilution method, let us try starting the engine without a preliminary warm-up; and, under summer conditions, we can guarantee the plane will take-off without a preliminary warm-up right after starting the motor.

Technique of Diluting Oil With Gasoline

After a flight the oil is generally diluted with the gasoline used in plane engines.

The diluting can be done in two ways. It can be done with a special regulating valve connecting the fuel system with the pipe line of the oil supply. This is checked by the time of opening the valve and by the oil pressure. With this method, the diluting can be done without stopping the engine.

It can also be done by pouring the gasoline directly into the oil tank in a fixed, accurately measured quantity (this method requires stopping the engine).

Both methods require the temperature of the oil to be not above 40-50 degrees centigrade, since otherwise a large proportion of the gasoline evaporates.

Particulars of Engine Operation on Diluted Oil

If oil dilution with gasoline is effected while the engine is being used, certain particulars about the operation of the motor must be considered.

It must be realized first of all that when the plane is in storage it is possible for oil or gasoline to penetrate into the engine. This is particularly dangerous for radial engines when oil falls through the diluting system into the cylinder combustion chambers located below (for example, cylinder number 9 of the AM-82 FH motor), for it may cause a hydraulic impact.

In order to determine whether there is excess oil in the combustion chamber, the crankshaft is turned by turning the propeller manually. In this case, when there is a great deal of excess oil, the propeller can not be turned.

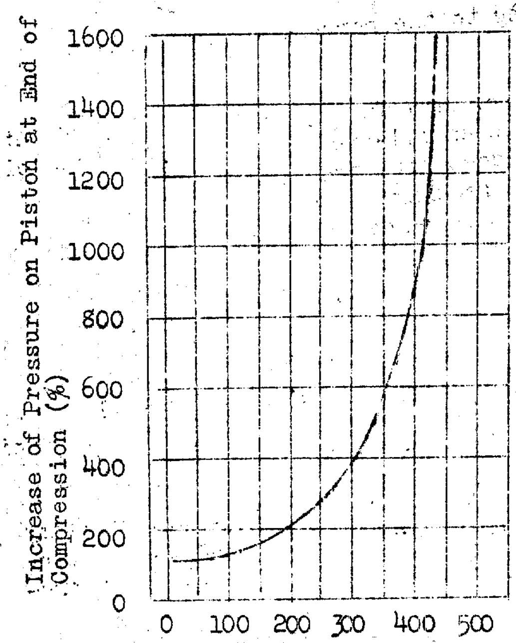


Fig 5 Amount of Liquid in Combustion Chamber (cm)

Figure 5 shows the relative increase in pressure on the piston and the cylinder wall at the end of compression, if there is oil or gasoline in the compression chamber. It is evident from the diagram that 200 cubic centimeters of liquid in the compression chamber can cause a double stress on the piston and the cylinder wall, and a whole chamber full of oil can cause a huge increase in the stress. This tends to prevent turning the engine by the propeller or to bring about a hydraulic impact which, upon breaking out, perforates the cylinder or bends the connecting rod.

It should also be kept in mind that, if the crankshaft is turned sharply by manual turning of the propeller when the piston is in a position near top, dead center, there may also be great stress on the connecting rod and resultant damage.

To prevent hydraulic impact when an excess of oil or gasoline is discovered in the combustion chamber, one unscrews the spark plugs of the lower cylinders and, making sure the ignition is off, turns the propeller by hand for two or three complete revolutions. In this way, the oil and gasoline that has collected in the cylinders is completely removed. Then, after screwing in the spark plugs, the engine is started in the usual way.

Warming up the engine with gasoline-diluted oil is done on the basis of 1,000 to 1,200 RPM during the first 2 minutes for АШ-82ФН's, and 900-1,200 RPM for ВК-105's. To accelerate the warm-up, the number of revolutions is gradually increased, taking care that the engine operates without trouble and that the oil pressure in the main pipe line does not exceed 8 kilograms per square centimeter for АШ-82ФН's, and 11 kilograms per square centimeter for ВК-105's. The temperature of the oil is not considered here. If the pressure is raised above 8 or 11 kilograms per square centimeter, the engine is stopped to determine the cause of such an anomalous condition.

The plane should take-off only after the coolant in the motor reaches the minimum permissible temperature of 60-90 degrees centigrade, regardless of the oil temperature. Thus, only the oil pressure is observed, so that it does not exceed 11 kilograms per square centimeter for ВК-105's.

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For engines with air cooling, the minimum permissible temperature of the cylinder head is 140 degrees centigrade, and the oil pressure is 8 kilograms per square centimeter for АШ-82ФН's.

For idle running, the minimum oil pressure is 2 kilograms per square centimeter for АШ-82ФН's, and 1.5 kilograms per square centimeter for ВК-105's. If the pressure goes below this, a lowering of oil viscosity is indicated, which may result from excessive gasoline dilution.

Excessive dilution may interfere with the normal lubrication of the engine (half-dry friction). The engine may be thrown out of commission as a result of it (wedging of the crankshaft). Moreover, with excessive dilution, a great deal of foam is produced in the oil, which results in oil being thrown out through the breather.

As flight begins, when the engine is operating on diluted oil, the pressure in the main pipe line may drop below normal to 0.5 to 1.0 kilograms per square centimeter. However, after 20 to 30 minutes of flight, it is completely restored, since the gasoline almost completely evaporates during this time (figure 4).

Particulars on Gas Starting

Easy turning of the crankshaft before starting still does not solve all problems of starting in winter. For normal, steady operation, it is still necessary to have the operating mixture correctly formed and fed into the cylinders.

It is well known that the lower the temperature of the atmosphere, the more difficult it is to ignite the operating mixture in the cylinder. At temperatures below minus 10 degress centigrade, it is, practically speaking, quite difficult to start the engine without a preliminary warm-up. The situation is not improved by using special starting fuel. At the same time, in the heat of battle, the engine must be started for the take-off in the shortest possible time and, consequently, without a preliminary warm-up. And so, in the second half of the last war, gas starting began to be used, based on obtaining and using fuel gasses and feeding them into the cylinder of the engine.

The gas mixture, obtained from the portable gas generator of the airdrome, is introduced into the intake system of the engine when the crankshaft is being turned.

The gas generator is an ordinary АПЛ-1 heating device further equipped with a coil pipe, regulating valve and two pressure guages.

The basis of the generator is the coil pipe, intended for heating the gasoline and transforming it into gas. Under pressure from a pump, the gasoline passes from the tank into the coil pipe, located under the burner, and through the regulating valve. The flame of the burner, enveloping the coil pipe, heats it to 600-700 degrees centigrade. The gasoline, proceeding through the heated coil, is converted into a gas-vapor mixture easily inflammable at low atmospheric temperatures.

This mixture is drawn into the intake system of a ВК-105 engine through knee pipes installed against the flow to insure even admixture with the incoming air. For АШ-82ФН engines, the mixture goes into a slot formed by the forward wall of the throttle case and the throttle. Such a method of introducing gas into the engine permits regulation of the quantity of mixture entering the intake system between sparks. It is consequently much easier to start the engine and get it into operation from the carburetor or the НВ pump.

If the gas generator is operating properly and the pressure is 2.0 to 2.5 atmospheres, a strong, colorless stream of gas should issue from the end pipe [бортовая трубка] into the atmosphere. The expenditure of gasoline in this process is from 300 to 500 cubic centimeters per minute.

After making sure that the end pipe and the intake tube [штуцер] are clean, one end of the pipe is connected with the heating device and the other to the intake tube, the pressure in the tank being kept down to 3 atmospheres. Six to eight seconds after starting to feed in the gas-vapor mixture, one starts the НВ-3У pump (АШ-82ФН engine) and opens the air valve of the ПН-1 pump.

Then the ignition is switched on. After a few sparks, the magneto is turned on, and the pressure of feeding gasoline into the coil pipe is raised to the point indicated on the chart.

Temp of Outer Air (°C)	Req Press of Gasoline Entering Coil Pipe Before Motor Starts (at)	Same, After the First Sparks
0 to -5	0.5	1.5
-5 to -10	1.0	2.0
-10 to -15	1.5	2.0
-15 to -20	1.5	2.5
-20 to -25	2.0	2.5-3.0

The established pressure is maintained all during the engine warm-up, and until the gasoline starts being fed from the НВ-3У pump. As soon as the engine begins to operate, the booster coils are shut off, and the air valve of the ПН-1 pump is closed.

The warm-up of the engine while it is being fed gas-vapor mixture is at 500 to 600 RPM. At the time of starting, the throttle of the air passage into the engine should not be opened more than is necessary to maintain 500-600 RPM. Further increase in the proportion of air entering the intake increases the number of revolutions and, consequently, brings about a marked weakening of the mixture, which is accompanied by backfiring, sometimes with a flame exhaust.

Keeping the Engine Warm

To avoid excessive loss of heat in starting or operating an engine, all pipe lines beyond the fire partition, the oil tank and the shells of the oil and water radiators are heat-insulated. Moreover, in the sheds, the whole engine-propeller unit is covered with a warm hood, and the radiators are covered with warm protective cushions.

The engine may be kept warm by several methods: with a heating lamp, catalytic stoves or by circulating warm liquid through the cooling system of a liquid-cooled engine.

Sometimes an engine is kept warm by periodic starting. This method must be condemned, since, in the first place, it wastes a great deal of fuel and, secondly, soon wears out parts of the engine. Experiments have shown that wear and tear on the engine is considerably greater in starting than in a long period at normal operation. Thus, for example, the average wear and tear on the hub of the main piston of the engine of an -25 for 100 hours of operation is 4 microns; while the average wear and tear in 100 startings under winter conditions is 9 microns. That is, the wear and tear is more than double.

After operating, a warm engine should be carefully covered with a hood, so that it will cool off as slowly as possible. In figure 6 are graphs of the progress of cooling a plane engine in a shed. The difference in cooling the engine when covered with a hood and when not covered is evident from these graphs.

Other heating methods presuppose the use of special airdrome means. These include heating stoves, not only burning, but also fireless (the so-called catalytic stoves). When stoves are used to maintain the requisite temperature, they must be carefully watched to avoid accidents.

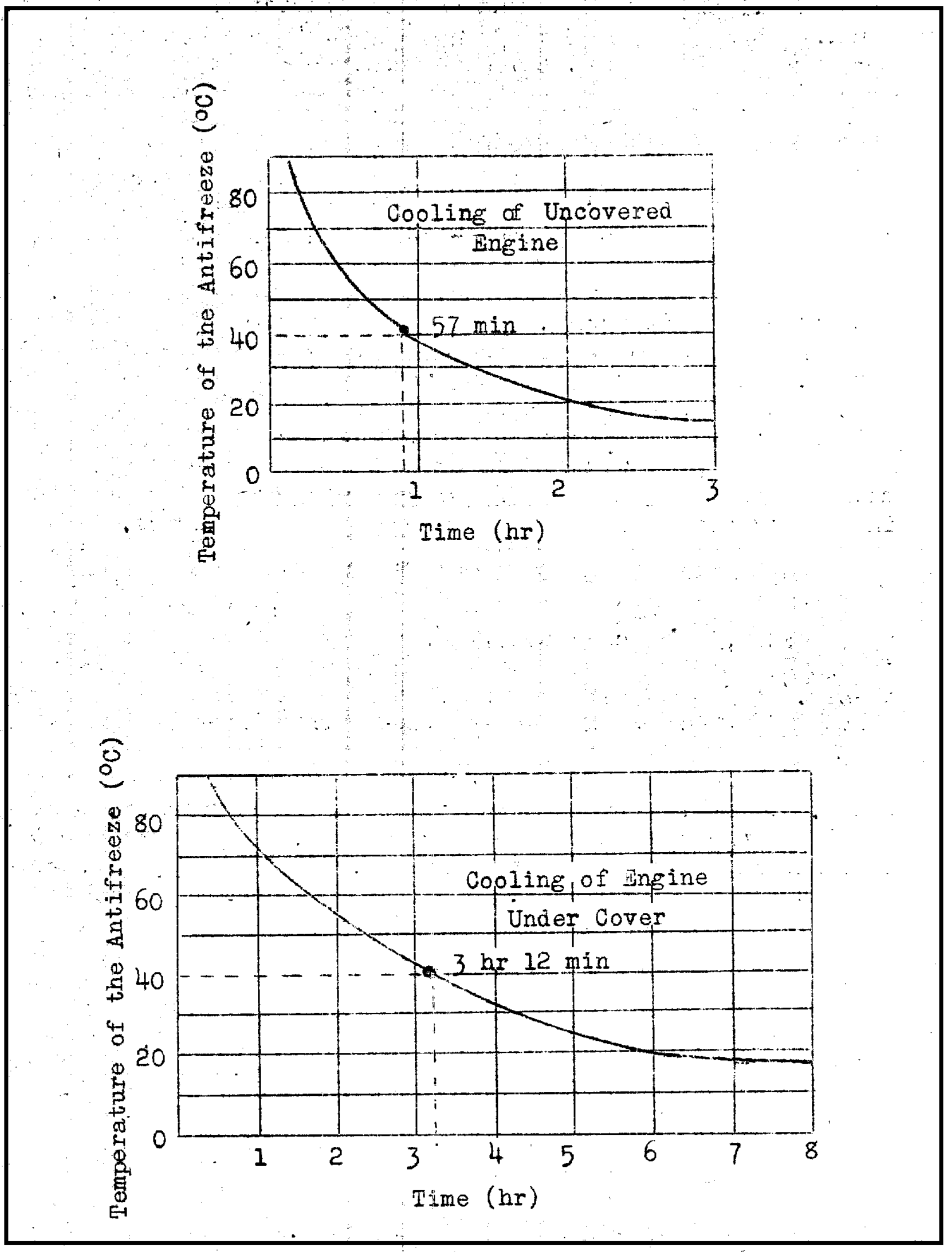
Temperature of the Antifreeze (°C)
80
60
40
20
0
1
2
3
Time (hr)
Cooling of Uncovered Engine
57 min
Temperature of the Antifreeze (°C)
80
60
40
20
0
1
2
3
4
5
6
7
8
Time (hr)
Cooling of Engine Under Cover
3 hr 12 min

Fig 6

TECHNICAL MAINTENANCE OF JET AIRCRAFT IN WINTER

Lt Col B. Zakharevskiy (Engr)

In the present article, we shall try to analyze the particulars of the technical maintenance of jet planes under low-temperature conditions.

The main peculiarities of servicing during this period are the necessity of heating the turbo-compression, air-jet engines (ТКВРД) before starting them, keeping them warm, and keeping the oil in the plane's lubrication system at a sufficiently high temperature (unfortunately, the oil was not diluted with gasoline, and it is therefore impossible to report on that question). The latter condition guarantees normal operation of the automatic regulators of the engine after starting.

Moreover, in regard to ТКВРД 's, it is necessary to check the fuel used here (kerosene) more often than usual.

When the temperature of the surrounding atmosphere is near 0 degrees centigrade and below, reliable starting of a ТК ВРД installed in a plane is impossible without preliminary heating. Powerful calorific heaters are a better means of heating. Their productivity is from 50 to 60 cubic meters of hot air per minute, produced at a speed of 10 meters per second and at a temperature of 120-130 degrees centigrade upon leaving the heater.

The warm air is expelled into the engine to heat the combustion chambers with their spark plugs and the starter (of the two-stroke piston engine) used to limber up the motor before starting.

ТК ВРД's (with axial compressors) installed in planes permit hot-air heating by various methods: (1) from the front---from the diffusor; (2) from the back---from the jet nozzle; and (3) into the windows in the outer shell of the support drum (in some types of ТК ВРД's these windows are located opposite the spark plugs and the fuel injectors of the combustion chamber).

Of these, the best method is the second, since then the hot air is fed into the combustion chamber most quickly.

This method should be particularly recommended for planes with fairly long intake tubes (1.50-2.0 meters) bringing air to the engine. The hot air is fed from the heater to the engine through the ordinary hoses tipped with metal nozzles of a shape to permit the most satisfactory feeding of hot air through the circular passage between the nozzle and its needle (cone). When the current of hot air fed from the heater passes through the whole engine, beginning with the jet nozzle, through the turbine, the combustion chamber, and the compressor, and goes out into the diffusor, the time of heating the engine before starting is considerably shortened; also, a good heating of the starter is assured. In this case, to lessen the resistance to the movement of the hot air, the pipe covers of the diffusor are left slightly open in the upper part.

The time of heating an engine covered with a warm hood (when the plane construction permits) at atmospheric temperatures from 0 degrees to minus 15 degrees centigrade is 10-20 minutes.

Success in starting a TK BPД depends first of all upon successful activation of the starter (two-stroke gasoline engine), also on favorable conditions necessary for igniting the starting fuel in the combustion chambers.

However, it is necessary to note here that, although there is adequate heat, the starter often fails to operate for another reason---mainly, failure of the spark plugs to operate as a result of greasy electrodes. In most cases, the cause of greasy electrodes is an excess of oil added to the gasoline to operate the starter.

At atmospheric temperatures from 0 degrees to minus 5 degrees centigrade, the oil content of gasoline for the starter should not exceed 2 percent; and, at temperatures below minus 5 degrees centigrade, only pure gasoline should be used without any addition of oil.

It should be noted here that at temperatures of 0 degrees centigrade and below, it is better to use lighter gasolines or special starting types of gasolines as a starting fuel, both for the main engine and the starter. This makes it considerably easier to start a jet engine.

The mixture of gasoline and mineral oil as a starting fuel for the engine is poured into the tanks through a silk filter (use of chamois is not recommended, as it filters the oil out of the mixture).

Careful filtering is required first of all in feeding gasoline to the injectors of the combustion chambers in planes with check valves. This is necessary, because the slightest fleck falling under a check valve can cause a fire in the engine when it is stopped or started.

The normal operation of a TK BPД depends upon the normal operation of the automatic devices installed in the engine, the regulator of the number of revolutions, and the regulator of the movement of the cone (needle) of the jet nozzle. The latter operate as part of the general lubrication system of the engine, being units with hydraulic drives. The most important factors here is the viscosity of the oil, the operating fluid of the regulators. Therefore, to decrease the viscosity of below-zero temperatures, the oil in the lubrication system of the plane should be put in heated from 90 to 100 degrees centigrade. After flights are completed, the oil must be completely drained from the lubrication system of the engine.

Although the starting of TK BPД's in winter is done in much the same way as in summer, it is nevertheless worthwhile to go into a few peculiarities and difficulties therein.

In winter the engine is started more easily by switching on the ignition and the motor of the gas pump earlier (about 200-300 RPM earlier than in summer).

Due to the temperature of the atmosphere, the power consumed by the compressor is increased, and therefore the power of the starting motor and the turbine operating on gasoline can become insufficient to limber up the engine to 2,000 RPM. In this case, switching the feeding of the engine to the main fuel (kerosene) is recommended at 1,500 RPM and above.

Moreover, it should be kept in mind that, due to clogging (freezing) of the drain holes or drain pipes of the gas tanks, there may be failures to start, not only on the part of the starter, but the main engine as well, when they are used under winter-temperature conditions. The indication of clogging of the drain holes is a break in the operation of the starter (the motor "cuts") or a sharp decrease in pressure of the gasoline being fed from the electric gas pump.

To keep the engine quite warm between startings, it is necessary to close the diffusor and the jet nozzle carefully with the pipe closers on the plane right after stopping the ТК ВРД. A warm cover should be placed on planes whose construction permits. If, due to operating conditions, it is necessary to keep the engine warm for a long time, hot air may be used from time to time.

The heating period depends upon the temperature of the atmosphere and the wind.

Therefore, it should be noted that, generally, at temperatures from 0 degrees to minus 5 degrees centigrade and in a weak wind the engine can be easily started without preliminary heating not more than an hour after being switched off.

The last question which need detain us is the check on the main fuel, kerosene. Since kerosene is more hydroscopic than gasoline, it is possible for moisture crystals (moisture freezing) to form in the fuel system of the plane at low temperatures. The crystals may cause congestion of the fuel filter and, consequently, cut off the fuel feeding. The sign of such a development is a sharp shaking of the needle of the kerosene pressure guage.

It is therefore recommended that samples of kerosene be taken every 3 to 5 days from the fuel system of planes, kerosene feeders and storage places for analysis of their moisture content. If moisture is present, the kerosene should not be released for use.

METHODS OF USING AIRDROMES IN WINTER

Lt Col V. Khar'kov (Engr)
Candidate in Mechanical Sciences
Maj A. Tkachenko (Engr)

Winter conditions present a whole series of problems in the use of airdromes. One of these is regular packing of the snow cover. This problem is particularly important now that the combat units of the army air forces have extensive equipment whose normal operation requires larger airdromes as well as improved methods of using runways in winter. In view of the fact that the preparation of a whole summer field, with an area of more than a hundred hectares, presents considerable difficulties in the case of heavy snowfalls and requires very expensive mechanical means, generally only separate runways are prepared. The direction of the runways should coincide with the direction of the prevailing winds in winter.

However, with the approach of spring or in the period of winter thaws even a well-packed snow cover loses its regular carrying capacity. Deep ruts form on the runway, which frequently prevent its use in summer. It is consequently necessary to look after such features of airdromes during the winter so that natural phenomena do not interfere with flights. This can be done by clearing the runways of snow instead of packing it. In clearing a runway, only such a layer of snow may be left as will not affect landing or taking-off, even if the wheels of a plane break through it during a thaw.

The answer to the problem — at what airdromes must runways be cleared of snow and at what airdromes should the snow be leveled— depends greatly not only upon strategic requirements but also upon geographical conditions. For example, in areas where winter conditions are stable and there are no thaws during the winter period, there is no sense in clearing the runway in the course of the whole winter. Where thaws are noted and regular flights are made from the airdrome, regular clearing of the runways is necessary.

Methods of preparing an airdrome for winter use are chosen with an eye to its function. The simplest and most widespread method is regular packing of the snow. This is begun after the first snowfalls. Then it is necessary to see that the snow has a density of not less than 0.5 kilograms per square centimeter, and that the covering can support a pressure of at least 5 kilograms per square centimeter. The depth of the ruts left after a plane run must not be more than 3 centimeters.

The snow should be packed with rollers and square set-hammers from the beginning of the snowfall until it stops. Mounds and drifts must not be permitted to form on a runway because it takes extra work to level them off.

Square set-hammers used for packing should have an inclined bottom to create a greater specific pressure. The rollers may be of metal or wood, from 3 to 5 tons [T] in weight. Their disadvantage is that they can not level out a runway, since the actual contour lines are not affected by the rolling process.

When the temperature of the air is below that of the upper layers of snow, it is generally unwise to use rollers since in this case snow will stick to the roller, a cooler surface. Then the rollers do not pack the covering but turn it up and rumple it. Therefore, in the technique of using airdromes in winter, НИАС square set-hammers are in widest use, creating a specific pressure such as rollers do if they are loaded to a certain point with ballast. The hammers are preferred because they level the surface of the strip at the same time as they pack it.

In recent years in America, rubber rollers have had a widespread use in the construction of airdromes and roads. Due to the resilience of the rubber surface the roller has a higher temperature, and snow never sticks to it.

In consideration of these qualities, the Airdrome Scientific Research Institute of the Army Air Forces recommends the use of rubber rollers made out of old automobile tires. These tires (up to eight of them [ШТ]) are put on a wooden core, the diameter of which is equal to that of the inside of the tire. Such a rubber roller is always used successfully with a ballast up to 2 or 3 tons [T].

The best results, however, were obtained by a combination of several rubber rollers (up to five of them [ШТ]) operating in concert with a hammer with an inclined bottom.

It is recommended that the surface at a runway be packed with rollers and hammers from three to five times. A greater number of operations, with the same specific pressure, does not increase the firmness of the covering and leads only to a waste of fuel.

Because the lower layers of snow are coarser grained, down to the névé (TN: granular layer) and the upper ones still have their clear crystalline character, consisting of finer, independent flakes, the snow cover is a variegated mixture. To obtain a uniform mixture and to extract the air, the snow must be mixed up. After mixing, which is not recommended at a temperature above minus 5 degrees centigrade, the snow settles all over, its density is almost doubled, and the temperature of the whole mass is lowered.

In the mass of a snow cover overturned in this manner, favorable conditions are created for sublimation of water vapors, that is, for their passing into a crystalline deposit.

Sublimated deposits and water films play the part of a cement solution. They are formed mainly in places where crystalline contacts and joining take place.

If, in mixing the snow, additional warmth is introduced in the form of escaping gases from the motor in operation or any other means of adducing warmth is used, the snow can be further packed and consequently the firmness of the cover greatly increased.

Such a firm cover on a deep substratum of snow is made when the unexpected necessity of building an airdrome after a considerable accumulation of snow arises. A snow cover over 30 centimeters thick can be packed only after mixing it up. For mixing it, a special wooden spiketooth harrow can be used with an agricultural cultivator and automobile tracks. (TN: like tractor tracks).

Following the mixing equipment and acting in concert with it, a square set-hammer is required to level off the surface. Ahead of the mixing equipment the snow is like dry gravel in which the feet stick. This is explained by the fact that the cementation proceeds gradually. In proportion to the cooling of the whole mass (a process of 6 to 8 hours), the mixed snow can sustain a load at an atmospheric temperature of 5 at most. Eight to 10 hours after the mixing, the surface at the runway must be treated with rollers.

By careful mixing and heating of the snow cover with exhaust gases, a runway able to sustain a stress up to 15 kilograms per square centimeter can be obtained. Actually, not only airdromes but road coverings are also made this way.

As mentioned above, at airdromes in places characterized by winter thaws, the runways must be cleared of snow. Previously, this method was used in order to start using runways as soon as possible in spring. But sometimes it had the opposite effect. Thus, for example, if heavy soil were cleared of snow for the whole winter, the soil in this portion would freeze very deep. A large amount of moisture accumulates in thin layers of ice the soil contains, and such a runway can not be used until later in spring than the surrounding territory can.

Another disadvantage of clearing snow down to the ground is the fact that many turf-forming grasses die when the snow is removed. This is partly due to freezing and partly because the machines used destroy the upper layers of sod.

Snow should not be cleared from artificial (concrete and other) runways of the hard type by machines operating by tractor reaction because the concrete may be damaged. Moreover, if the soil is heavy and there is water near the surface of the ground, a disturbance of the concrete covering is sometimes noted. This also results from deep freezing due to clearing runways of snow. Snow should be cleared from earth runways in such a way that it is deposited on the adjacent shoulders, where it should be leveled off and packed.

In the present article we shall briefly consider three systems of snow clearing.

1. The snow is shifted from the runway to its shoulder, where the so-called "layout" (leveling it off and packing it) takes place. "Layout" of snow is permissible when the coutour prevents the runway from sinking due to the water formed when the deposited snow melts, or when reliable drains can be constructed.

2. The snow is removed from the runways to a special dump. This system is possible when there is a depression not more than 200 meters from the runway with approaches on which to bring up the machines. This system is more economical than the first, since it does not require leveling and packing.

3. The snow is removed from the runway beyond its shoulder, from where it is immediately taken to the dump. This system is the least economical. It should be used only when the two above can not be. Then, only a minimun of snow need be carted off, using a combined system.

At the present time two types of equipment are used for snow removal by airdrome units: the universal НИАС sledge and the rotor snowsweeper "Snogo". Positive results were shown by these machines during the last war. With them, airdrome units successfully performed snow clearing operations, allowing aircraft to maintain continuous combat activity.

In view of its simple construction, we shall not give a description of the universal НИАС sledge, but we shall dwell briefly on the description of the rotor snowsweeper "Snogo."

Beginning with the winter of 1944-45, at some army air force airdromes, snow was cleared from runways with rotor snowsweepers of the "Snogo" type. These machines, mounted on automobiles, are self-propelled units and operate by collecting snow lying in front of them and throwing it aside. The capacity of this sweeper is about 400 tons /T/ of snow per hour. Then, the snow is scattered on the runway to a width of 20 to 30 meters. The snow is collected by conveyers and thrown aside by a rotor constructed like a ventilator. The unit has two independent engines to propel it and to clear the snow. In one run, a strip 2.3 to 2.5 meters wide is cleared.

Runways are cleared by a multiple, consecutive handling of snow, because the snow passing through the rotor is thrown on the unswept strip until the sweeper approaches the edge of the runway.

As a result of such sweeping of a runway, the volume of snow which has passed through the sweeper is considerably greater than that cleared from the runway, and the average output of the unit is less than its productive capacity. The wider the runway the greater the discrepancy is.

From the above, it follows that to determine the time and quantity of fuel necessary to clear a runway, not only the amount of snow but also its density must be considered, and most important, the width of the strip being cleared.

At a wind velocity of over 5 meters per second, the operation of a rotor sweeper against the wind is unsatisfactory because the snow is blown back on the cleared field. Therefore, runway clearing should be so arranged that the snow is thrown with the wind. The sweeper should operate against the wind only when the velocity of the opposing wind is not above 2 meters per second.

Snow clearing can be done not only toward one but also toward both sides of a runway. In the first case, the removed snow is successively thrown beyond the shoulder to the designated dump for snow. In this system the runway is cleared in one process; that is, the snow is removed from one edge of the runway to the other regardless of the increasing depth and density of the transferred snow.

To facilitate the work on the second half of a runway the sweeping on one side should be done in two steps. First, the second half is cleared from the middle of the runway to the edge, and, then, the whole surface of the runway is cleared as described in the preceding example.

The time standards for clearing a runway 1200 meters long, in relation to the width of the runways and the depth of the snow, are given below (in machine hours):

Width of strip to be cleared (m)	Depth of snow cover to be removed (cm)							
	5	10	15	20	25	30	35	40
100	6	11	16	22	27	33	38	44
150	10	20	30	40	50	60	70	80
200	14	28	43	57	71	85	100	114

It is assured that the snow has a density of 0.15.

Clearing toward both sides is less economical than the method described. In this method, the whole area of the runway is divided into two equal parts on a longitudinal axis. The snow is removed from each half over the corresponding edge. Each half in its turn is divided into two strips and cleared, as in the preceding example, in two steps.

The time standards for clearing a 1200-meter-long runway of snow with a density of about 0.15, in relation to the width of the runway and the depth of the snow are given below (in machine hours):

Width of strip to be cleared (m)	Depth of snow cover to be removed (cm)							
	5	10	15	20	25	30	35	40
100	7	14	21	28	35	43	50	57
150	16	32	49	65	81	97	114	130
200	28	57	86	115	114	172	200	230

An apron is formed at the edge of the strip after the first sweeping, the height of which depends upon the quantity of snow removed.

If appropriate measures are not taken after each sweeping, the height of the apron at the end of the winter can reach 1 meter or more. It considerably decreases the width of the strip and is even an actual obstacle to flying.

The surface of the runway can be made level with the adjacent surface by the rotor sweeper and packing devices (rollers and hammers).

Removal of snow from runways by the indicated methods and the help of the equipment mentioned has been carried out successfully by several airdrome units. Therefore, the above-mentioned means should be widely used in the winter of 1947. Special attention must be directed to the use of runways in regions where winter conditions are unstable and frequent thaws occur.

AVIATION ACTIVITY IN AN ENCIRCLEMENT

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The majority of Red Army offensive operations in the war, from the Stalingrad battle to the battle for Berlin, were concluded an encirclement and liquidation of a large group of the enemy. The characteristic peculiarity of these battles was that enemy troops were often encircled in large towns (Budapest, Poznan, Breslau, Gdansk, etc), as a result of which the Soviet troops had to fight intensive street battles.

In all these operations our Army Air Forces played an active part. Usually, well before the moment of complete encirclement of an enemy group, aviation had brought about a condition favorable to the execution of this mission by acquiring air supremacy, disrupting enemy communications, and helping mobile troops operating on the enveloping flanks. From the moment the operational encirclement developed into a tactical situation, the Army Air Forces directly participated in the liquidation of the encircled group.

Experience in the last war showed that the main aviation missions during this period were as follows:

1. Direct support of land forces which have encircled an enemy group.
2. Repulsion of enemy air attacks and cover for own troops.
3. Resistance to enemy attempts to break through the ring of encirclement.
4. Blocking the encircled group from the air.
5. Neutralization and liquidation of the encircled troops.

The outcome of encirclement battles depended considerably on whether the attacking rifle formations forming the ring of encirclement were able to maintain contact with the mobile troops. Realizing this, the enemy attempted to stop the movement of rifle units with all their forces. Such attempts, as experience showed, were successfully repulsed by aviation supporting attacks. Thus, to a certain extent, it replaced artillery. In most cases the latter was engaged in other missions during this period.

Under these operational conditions, the land troops frequently had to overcome enemy screening forces, with the help of which the enemy tried to withdraw their troops from the encirclement. This mission was generally accomplished by rifle formations directly cooperating with their aviation.

For the land troops completing the tactical encirclement the cooperation of aviation meant chiefly the organization of systematic reconnaissance of enemy troops, an escort for tanks and infantry, opposition to enemy reorganization within the ring of encirclement, and an air cover. Experience in the last war proved that concentrated air attacks and continuous air escort for attacking elements aided the land forces to a considerable degree.

During the period of completing the encirclement of the enemy group, the enemy almost always increased his air activity, the force of which, as wartime experience showed always depended upon the degree of neutralization of the opposing Army Air Forces.

However, even when we acquired adequate air supremacy, the enemy still tried to stop the Soviet offensive with supporting attacks by small groups of their fighters.

Air cover of land troops who have encircled an enemy group was effected chiefly by concentration of the efforts of fighter formations in the main attack sections. In the most decisive periods of aerial combat, powerful fighter patrols (15-20 planes) were constantly on duty skirting the area of encirclement and intercepting enemy aviation. In other cases they were dispatched to duty in the air at approaches to the encirclement area. Their mission was to oppose the approach of enemy aviation to our troops' combat area. Thanks to this cover, our land troops, having encircled the enemy, were free to maneuver and to direct all their efforts to the liquidation of the encircled group.

During the last war, there were cases where the enemy, trying to break through the ring of encirclement and withdraw his troops from it, concentrated large forces of his aviation at narrow portions of the front (Korsun-SHEVCHENKOV* operation, Budapest). Sometimes the enemy made 1000-1500 flights a day for this purpose. Under these circumstances, our fighter aircraft, after covering the land forces that had encircled the enemy group, had to fight fierce air battles to repulse enemy air attacks.

All this required especially careful organization of the direct fighter cover for the land troops in an enemy encirclement because successful repulse of enemy air attacks accelerated the offensive and gave us wide freedom in maneuvering.

Fighter cover for land troops generally effected by the following methods:

1. Patrol duty by powerful groups of fighters at probable approaches to the area of encirclement.
2. Fighter escort for combat support and bombardment aviation on combat missions.
3. Patrol duty at airdrome of fighter units and elements to increase forces during the period of repulsing enemy air attacks.
4. Concentration of large fighter forces over encirclement areas in periods of decisive attacks on encircled troops,
5. Blocking of enemy airdromes by fighters in very critical periods of conflict with encircled troops.

After completing the encirclement, one of the main aviation missions was to take part in repulsing enemy attempts to break out of the ring. The prime requisite for successful execution of this mission was the concentration of aviation efforts against a very powerful and formidable enemy group. This became especially important when the enemy tried to smash the encirclement by counterattacks by the encircled troops. For example, in the Korsun'-SHEVCHENKOV* operation, the Germans shifted the directions of their counterattacks four times, moving them from east to west on the ring of encirclement. Our supporting aviation also shifted its blows accordingly to strike the counterattacking units and formations.

During the liquidation of the enemy group that was encircled in Budapest, enemy counterattacks were directed against a stiff counteroffensive from three directions: from KOMARNE*, AT ESTERHOM* and north of Lake Balaton. Our aviation had to show the greatest flexibility and maneuverability at this time, shifting its efforts from one sector to another and continuing the annihilation of the troops encircled in Budapest at the same time. Concentrated blows by combat support and bomber aviation on counterattacking enemy troops not only helped to repulse enemy attempts to break out of the ring of encirclement but also made conditions favorable for the successful liquidation of the group.

The experience of the last war indicated that an encirclement cannot be considered quite complete unless the enemy group is blocked from the air. The Germans usually tried to use transport aviation to deliver ammunition, fuel, rations, and medical supplies to encircled troops, and also to withdraw the wounded. This went on to an especially great extent in the encirclement of the German armies at Stalingrad and in the Korsun'-SHEVCHENKEV Operations The number of transport planes that maintained contact with encircled troops there ran into the hundreds. Therefore, opposition to them took on the greatest importance and required very large air forces.

Blockade of encircled enemy troops from the air was usually effected by aerial combat, army air force assaults on the main enemy transport aviation airdromes, blocking these airdromes with fighters, and destruction of enemy transport planes on the landing fields by combat support aviation.

The neutralization and destruction of encircled troops, as we have already indicated, is one of the most important missions of aviation in support of land troops. Generally, neutralization by aviation of enemy troops undergoing encirclement began well before the encirclement was completed and continued afterward. In the last war, neutralization and destruction of encircled troops were different.

In some cases the enemy groups were neutralized in the course of combat to the point where they could not put up a serious resistance at the time the encirclement was completed. In other cases, the enemy put up a stiff struggle for a long period, and the liquidation of the groups almost became a matter of annihilation one by one. Sometimes neutralization of encircled troops dragged out for a very long period, but their liquidation simply amounted to hunting disorganized groups roaming the woods. Finally, liquidation of encircled enemy troops in large towns had its peculiar characteristics. All this had a real effect upon aviation operating methods.

For example, in the Babruysk operation of the first Belorussion Front, combat and bomber aviation had a continuous effect on the troops of the Zhlobin enemy groups from the moment of its withdrawal northwest to the Berezin River. On 27 Jun 1944 the encircled enemy units were concentrated southeast of Bobruysk in the area of Titovka and Savichi. The intention of the German command was to break through the ring of encirclement by a tank group attack (150 tanks) to the northwest. Since the road junction of Titovka was at this time occupied only by advance units of our mobile troops, there was a real danger of the enemy's withdrawal from the ring. However, our aviation's concentrated attack on the encircled troops eliminated this danger. As a result of continuous air attacks lasting an hour and a half, the enemy troops were thrown into a panic. The German officers and men, abandoning everything fled to the Berezin River, swam across, and surrendered to our units, who had occupied the western bank of the river. On 28 Jun our troops, who approached from the east, occupied this area without any resistance.

In the encirclement of enemy groups at Korsun- SHEVCHENDOV* (Jan 1944) and at Brod (Jul 1944) aviation activity was of a somewhat different character. Thus, the Brod group resisted stubbornly for 72 hours after the final encirclement. They sustained huge losses and were crushed only after a concentrated attack by our aviation.

In the Minsk and Yassko-Kishinev operations the "kettles" that were formed were of a mobile nature. For example, in the Minsk operation, as a result of the swift offensive of troops of the Third and First Belorussian Fronts, by the end of 3 Jul 1944, 22 enemy divisions, extending 100 kilometers were encircled southeast of Minsk. Pursued by troops of the Second Belorussian Front and under strong blows by our aviation, they moved westward slowly in disorganized groups. Our troops literally had to comb the area ahead and hunt out the enemy units. In this task, supporting aviation gave very real assistance. It sought out detached enemy groups in the woods and swamps, overwhelmed them and directed our land forces to them. Our aviation, in order not to be separated from our troops, had its base shifted to the airdromes west of the encircled enemy groups. As a result, the technical staff and the air base battalion troops had to fight ground battles with the withdrawing enemy units.

The role of aviation in liquidating encircled enemy troops in large towns (Poznan, Gdansk, Breslau, etc) involved several difficulties which were caused chiefly by the fact that our land forces under these circumstances had to fight for each block and even for separate buildings. Therefore, in order to provide them with the most effective air support, very careful preparation was demanded of the air personnel. First of all, detailed study maps were necessary. For example, during the battle with an encircled enemy in Gdansk, our plane crews used a map of the city on which all blocks were numbered. When there was stiff street fighting, combat and bomber aviation could cooperate with the land forces only on the basis of carefully considered organization. Assignment of targets and plane direction to targets were usually done by radio directing stations frequently located on the roofs of high buildings, almost at the battle line itself.

Commanders of combat (bomber) groups in support of troops fighting in a town usually got the number of the block to which they were ordered from their radio and using the large scale maps of the city, led their planes to the target.

In street fighting, aviation--especially combat support--frequently had to compensate for an insufficiency of artillery. Such an incident occurred at Gdansk on 23 Mar 1945. The enemy troops, surrounded in a 250 by 400 meter-fortress, resisted our units with stiff firing. It was necessary to neutralize the enemy fire weapons. It was impossible to use artillery for this purpose because artillery fire from positions located on one side of this point might strike our own units stationed on the other side. For the same reason, it was not even possible to use bomber aviation. Then it was decided to use fighters to neutralize the enemy troops surrounded in the citadel. Two groups of fighters (15 planes in all) carried out this mission, led by Guards Captains Provovikhiu and Savchenko. They divebombed the citadel from a height of 1200-1500 meters, dropping 250 kilogram bombs. In all, 15 bombs were dropped, of which 13 hit the target and only two fell outside it. As a result, enemy fire was neutralized, and our troops quickly overcame the enemy fortifications.

The activity of light-motored night bomber aviation had great significance in the neutralization and exhaustion of enemy groups encircled in large towns. It was not without reason that one of the German commandants declared after his capture that the worst thing for encircled troops were the regular attacks of night bombers, preventing officers and men from sleeping at night and driving them crazy.

Thus, aviation activity on behalf of land troops, in the form of bomber and combat support attacks on encircled enemy groups, was usually very effective because the enemy units at the time for the liquidation were usually concentrated in small portions of a given area. In this period of the battle, as the experience of the last war showed, all types of aviation can be used to annihilate the encircled troops. Tanks and self-propelled artillery should be subjected to air attack first since the enemy tries to break out of the ring of encirclement with their help.

Aviation, from the beginning of operations, brings about conditions favorable to the encirclement of a given enemy group by disrupting communications and interfering with bringing up reserves. Due to their mobility and great operating radius, the army air forces, upon completing the encirclement, have a chance to concentrate on repulsing enemy counterattacks in the most important areas. After the encirclement is completed, aviation blocks enemy troops from the air and prevents their receiving battle supplies from outside.

Army air forces begin the neutralization and annihilation of troops being encircled from the moment the enemy is threatened with encirclement and continue until the final liquidation of the encircled group. The main prerequisite for successful aviation acquisition of air supremacy, which permits aviation to concentrate its efforts on executing the most important missions and give the land troops freedom to maneuver.

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